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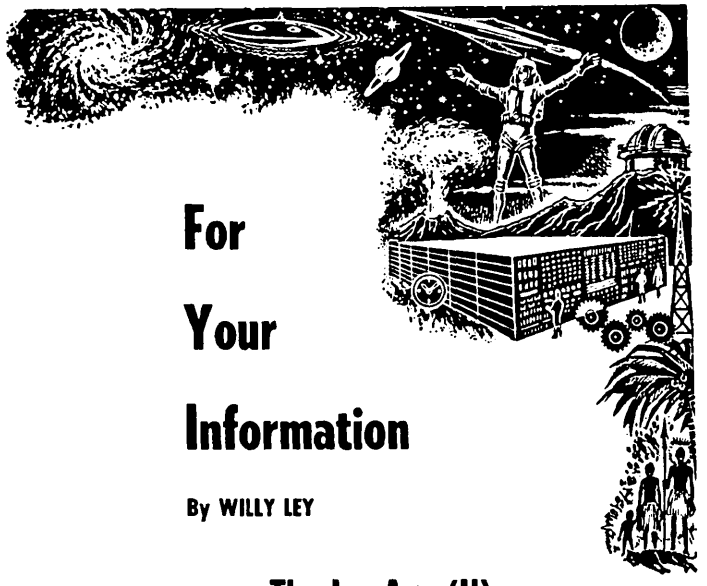
THE DEFENDERS By Philip K. Dick



For Your Information

By WILLY LEY

The Ice Age (II)

NOT just "once upon a time," but at least three times in the course of the last 600 million years, our planet experienced what is now called an Ice Age, a period of glaciers in areas normally free of them.

The first of these three glaciations, only very incompletely and sketchily known to us, took place in the earliest days of the old, old Cambrian Period. More likely it was at a time which we would call "pre-Cambrian," if

there were a hard and fast rule for placing the dividing line, and if we could date such distant events with any precision.

The next glaciation, of which we know much more, took place 400 million years later, during the Permian Period.

This period followed the days of the endless—both in expanse and in duration—swampy forests of the Carboniferous Period which produced most of our coal beds. The Permian glaciation was followed, however, by the three periods which are often lumped together under the term "The Age of Reptiles"—the Triassic, Jurassic and Cretaceous Periods—all in all, about 135 million years long and decidedly warm. The "Age of Mammals" or Tertiary Period—the name is a hangover from the early days of geology which assumed a total of four geological periods, of which this was the third—was of a total duration of 60 million years and also obviously warm in character.

And then, after a good round 200 million years of warm climate, there came the recent Ice Age which ended only a few thousand years before the very oldest records of human history.

THE great question, asked ever since even a few of the facts just recited became known, was "what caused it?" A set of answers which dominated thinking for quite some time was based on the simple reasoning that the Earth gets its heat from the Sun. Hence, if we did not get enough heat at one time, the Sun must have weakened temporarily, or else we, for reasons unknown, had been traveling in a different orbit.

In short, either the stove had not worked right or else we had been farther away from it.

Last month I gave a survey of these ideas and why they had failed to work out, sticking closely to the set of theories which had astronomical events in mind. Doing that, I had to disregard chronological order, else it would have been a confused story indeed.

Now for the set of theories which stayed on Earth. Just as there had been a simple-minded idea in the astronomical field (the Sun is burning out) there was an equally simple-minded thought in the geological department. After all, it was not only the Sun which was gradually cooling. The Earth was, too.

Once, the then current theory ran, the Earth had been a ball of hot gas and molten rock, a miniature sun. And although, because of its much smaller size, the Earth had formed a solid cool crust early in its career, it

had remained a miniature sun under that crust for a long time. In the days of the geological periods which were past, the crust did not only receive radiant heating from the ceiling, it was also supplied with heat from underneath. As that floor heating diminished, the crust grew cooler, for the Sun alone was not enough to produce the all-over tropical climate of the past.

The argument broke down as soon as that older glaciation of the Permian Period was discovered and confirmed. To make it completely absurd, somebody made a little calculation. Supposing that the heat from underneath was to provide as many calories to the surface as the Sun did, how soon would it become how hot if you dug down? The answer was that there would have to be almost red heat 35 feet below sea level—far from improving in growth, the roots of any large tree would be badly scorched.

SUBTERRANEAN heat was no answer. But, one might ask, granted that North America had had its Ice Age at the same time as northern Europe, and granted also that traces of an Ice Age had been found in the southern hemisphere, how could we be sure the Ice Age in the southern hemisphere had coincided with that of the northern hemisphere?

It was this thought which intrigued Monsieur Alphonse Joseph Adhémar, in everyday life a professor of mathematics, and which led to one of the wildest hypotheses ever to be thrown at a usually patient public.

But we have to recall a few elementary facts first. As everybody has learned at some time or another, the Earth's axis is tilted to the plane of the Earth's orbit, and the orbit itself is not a precise circle but merely a near-circular ellipse. At the present time, the Earth is farthest from the Sun when the northern hemisphere has summer. The slightly longer distance matters little; the important thing is that the tilt of the axis favors the north at that time of the year.

In the south, things are reversed; the South Pole has summer when the Earth is closest to the Sun. That, however, also means that the Earth is moving a little faster. Therefore the South Polar summer, while potentially somewhat warmer, is slightly shorter; the north has slightly cooler but longer summers. Conversely, the south has a colder and longer winter.

Then there is the phenomenon of the procession of the equinoxes —we can't go into detail here— which has the result that, in

twenty-odd-thousand-year intervals, the other pole attains the favored position of the somewhat longer summers.

Adhémar advanced the idea that the Ice Age was simply the time when the North Pole was in the position which now applies to South Pole. During those regularly repeating cycles when the tilt of the axis pointed the northern hemisphere toward the Sun, while the Earth was closest, the north had long and cold winters. Though the summers were hotter, they were too short to melt the ice which had accumulated. And the more the ice accumulated, winter after winter, the weaker the effect of the summer on that accumulation.

So far, this was, for the factual knowledge then available, a theory that could be seriously considered. But Adhémar did not stop there. As the ice accumulated around the unfavored pole, its weight shifted the center of gravity of the planet. This would cause the waters of the surface to assemble near the cold pole. Look at the map—the high north is largely land, but the massive ice of the south is surrounded by thousands of miles of sea water. Then, as the severity of the cold season slowly shifts from one pole to the other, the formerly ice pole melts clear. One summer the last ice floe disappears down there . . . and suddenly the center of gravity of the planet shifts and the waters hurry in an indescribable flood to the other pole.

During the last shift of the waters to the north, the mammoths were carried from their tropical homeland into the ice of Siberia, where they managed to live for one season—Adhémar could not know just how well the mammoths were adapted to a cold climate in every detail of their physiology—and the last water shift to the south was probably the Flood of the Bible. The next shift, Adhémar predicted in 1842, would take place 6300 years hence.

WHILE Adhémar erred on every count, he had introduced an idea which many a geologist tried to utilize later on: the notion that what *looks* like an ice age *may* just have been normal polar winter. But the poles may have been where they are not now.

About 1883, the Urania Observatory in Berlin had reported after considerable hesitation that its own latitude seemed to shift a bit. The amount was unimportant and hardly detectable. But the fact itself seemed—they said "seemed"—correct. The observatory of Pulkova in Russia was the first to corroborate the

strange news. Prague followed suit. Just to make sure, an astronomer, Dr. Markuse, was shipped halfway around the world to the Sandwich Islands to make measurements from an antipodal point.

It was true. The North Pole—and, of course, the South Pole, too—moves a little, some 70 feet away from its theoretical location. It is not a straight-line movement, but a kind of shivering—and no jokes about the low temperature, please.

Well, if the poles move a little now, they might have moved much more in the past. Look at a map again, a world map this time, or better still, a globe. Supposing that at one time the whole Earth had been turned in such a way that the North Pole had occupied the southern tip of Greenland. That would obviously have meant an Ice Age for both North America and Europe. Supposing that in the preceding geological period, the North Pole had been located under what we now call 60 degrees latitude in northeastern Asia. At that time the equator would have run through Texas and Louisiana on this side of the Atlantic Ocean, and through Spain and Greece on the other side.

It would certainly have been tropical in North America and Europe then.

THIS simple example which just shifts the pole along the 40th meridian does not work out in reality. For Ireland, England and North Germany, and, of course, Scandinavia, were covered by glaciers, while France and Spain were not.

But this was the general idea, set forth, for the first time to my knowledge, in the Annual Report for the Year 1901 of the Society for Geography in Dresden. The author of this particular paper was an engineer by the name of Paul Reibisch.

It seemed to Reibisch that the whole Earth performed a very slow pendulum movement, swinging in the course of geological periods north and south, bringing different continents into the tropics and under the poles. If you want to visualize what he meant, take a globe and hold it between two fingertips which are placed on Sumatra and Ecuador. Turn the globe back and forth. Now, if you can imagine that the ice cap of the pole slithers back and forth over the continents and seas, you know the gist of Reibisch's theory.

Reibisch followed up his original paper with two more publications in 1905 and 1907 and, in the latter year, another book appeared which enthusiastically supported Reibisch. Its author was Dr. Heinrich Simroth, pro-

fessor of zoology at the University of Leipzig.

Prof. Simroth had tried to coordinate Reibisch's geological ideas with his own knowledge of zoology, specifically the distribution of the animals over the globe, and had satisfied himself that everything worked out wonderfully.

Simroth did something else. Reibisch had introduced that pendulum movement as a fact; Simroth tried to find the reason for it. His solution: a second moon of Earth had struck several hundred million years before the first glaciation in pre-Cambrian days. This shock had caused the first movement, and ever since then, the magnetic field of the Sun, acting upon the magnetic field of the Earth, had tried to dampen the pendulum movement, until only the slight shivering of the poles is left now.

Very ingenious, but it has nothing to do with reality. Even forgetting Simroth's "elaborations," Reibisch's pendulum just does not work out. For one thing, while the European glaciation would fall between the Tertiary Period and the present, the North American glaciation would fall into the Tertiary. Geologists were quite sure even in 1907 that they were simultaneous. Now, thanks to the carbon-14 method, we know they were.

BUT there was one more thought. Possibly it was not the Earth as a whole which made weird movements, but only the Earth's crust or portions of the crust, floating upon the heavier magma of the next deeper layer. When you voice this thought now, everybody will think at once of Prof. Alfred Wegener's theory of the floating continents, an intriguing idea about which one may say that it *almost* explains things. But not quite; there are lots of difficulties left. Dr. Wegener, however, was not the first to make the crust of the Earth wander about the planet.

The first, in 1886, had been a learned and careful outsider, Karl Count Löffelholz von Colberg, who offered this thought as a possibility. The next one to make this suggestion was (strange coincidence of names) Father Kolberg, S. J., and the third was Father Damian Kreichgauer, S.V.D., who some fifty years ago published his *Die Aequatorfrage in der Geologie* which may be translated as "The Position of the Equator in Geological History." Father Kreichgauer was interested in the equator as the title shows, but if you move the equator, you move the poles, too.

Interestingly enough, Father Kreichgauer—who wrote before Reibisch published his works, even though the publication date

is a little later—also assumes that northern South America and the East Indies shifted little, if at all. Otherwise the equator is assumed to have almost "flopped over" in the course of geological history.

Since Father Kreichgauer's continents can wander off obliquely, if needed, things work out far better than with Reibisch's rigid system. But even so the glaciations of East and West cannot be made to coincide. In reality, they did.

ALL these ideas were not really explanations, They were attempts to explain the Ice Ages away, to show that unknown factors led to systematic mistakes in interpretation of the evidence. But since they all failed, the old assumption that the whole Earth was temporarily cooler is still the simplest and most logical. Nor did it have to be very much cooler. Melchior Neumayr of Vienna showed that a general reduction of the average temperature by just 6 to 8 degrees Fahrenheit is sufficient.

If every noon and every midnight is 6 to 8 degrees F. cooler than now for a number of centuries, we'll get the most beautiful glaciation, both in the north and in the south, both east and west—and no nonsense about shifting centers of gravity and second moons hitting us below the equator.

One rather obvious thought centers upon the enormous cosmic dust clouds we see in interstellar space. If our sun with its planetary system wandered into such a cloud, the dust would absorb some of the solar radiation and Earth would receive less heat. It is really surprising that it took so long until somebody actually said so, yet the idea did not reach print until about 30 years ago with a paper by the astronomer Prof. Nölke.

It seems simple, but the difficulties are enormous.

The cosmic dust would absorb solar radiation, all right. It would also reflect radiation which would normally miss the Earth. The final result might well be an increase of radiation reaching us! (In fact, the British Col. Delauney, writing at about the same time as Nölke, took this position.) More important, the dust would fuel the Sun, increasing the output of heat.

It is conceivable that you might wiggle through by assuming a density of dust in space of just the right amount to act as a shield without increasing the Sun's output more than the shielding. But since the last glaciers vanished only 10,000 years ago, it would be a reasonable demand to have the cosmic cloud

which caused the Ice Age pointed out in the sky.

More than thirty years ago, the geologist Geinitz, who could be considered the foremost authority on all the theories relating to the Ice Age, wrote in the introduction to a heavy volume on this subject: "The causes of the Ice Age are unknown." Unfortunately, he could use the same sentence if he wrote now.

But there is one more theory which I'll save for the next month. It cannot be proved, but it might be true in principle.

MORE "PI"

THE item on "pi" brought in a surprisingly large number of letters, among them six from correspondents who could not figure out just how a sentence about alcoholic drinks and quantum mechanics was supposed to help them remember the value of "pi" to 14 decimal places. I also received one letter (from Peter J. Sutro of Oklahoma City) in which he predicted that some readers would ask that question. I had to admit to Mr. Sutro that this was my fault.

The clue is, of course, the number of letters in every word. I had taken it for granted that the readers would catch on, if not at once, at least after about five minutes had gone by. Now I assume that everybody but those six readers did, which isn't at all bad.

An informative letter about "pi" came from Dr. James Stokley of General Electric's Research Laboratory. First of all, Dr. Stokley confirmed that the mnemonic I quoted was actually coined by Sir James Jeans; it appeared originally in a letter to *Nature* 25 years ago over the initials J.H.J., which were those of Sir James.

Dr. Stokley also informed me that the value of "pi" is now known to 2040 places. Only thirty years ago, that would have been the lifetime work of a mathematician, but times have changed. The calculation was accomplished by a group of researchers at the Aberdeen Proving Ground under W. Barkley Fritz. Working on their own time over the Fourth of July weekend in 1949, and using the ENIAC computer, they not only derived the value of "pi" for many more places than ever before, but also calculated the value of "e" to 2556 places. Anybody who wants to know more about this, please consult vol. 4, p. 11 (June 1950) of the *Mathematical Tables and Aids to Computation,* published by the National Research Council.

Several correspondents — first one in was William Vickrey of

552 Riverside Drive, NYC—sent me another mnemonic for "pi" which is good for 30 places and reads:

Now I, even I, would celebrate
In rhymes inapt, the great
Immortal Syracusan, rivaled nevermore
Who, in his wondrous lore,
Passed on before,
Left men his guidance
How to circles mensurate.

My personal feeling about this poem is that it would be easier to memorize "pi" to 30 places directly. Acting under the conviction that one bad poem deserves another, I replied with the French version which reads:

Que j'aime à faire apprendre un nombre utile aux sages!
Immortel Archimède, artiste ingénieur,
Qui de ton jugement peut priser la valeur?
Pour moi, ton problème eut de pareils avantages.

For good measure, I added a German version, constructed in 1878 by the mathematician Weinmeister:

Wie o! dies π,
Macht ernstlich so vielen viele Müh',
Lernt immerhin, Jünglinge, leichte Verselein,
Wie so zum Beispel dies dürfte zu merken sein.

When I thought it was all over, I received a stern-sounding postcard from Bill Powers of 111 E. Oak Street in Chicago, Ill., reading: "I wish I could recapture my memory about Sir Jeans' diabolic mnemonics! However, invention now of any reliable, easy phrase is beyond what shy and fumbling aid my present intellect gives."

Admittedly very fine and clever and certainly worth publication. But I have yet to find a case where 3.1416 wasn't good enough.

—WILLY LEY

ANY QUESTIONS?

Space, we are told, is swarming with meteors. What is their origin?

Robert B. Godwin
2539 Lyndale Ave. So.
Minneapolis 5, Minn.

Astronomers are pretty much convinced by now that the overwhelming majority of all the meteorites which we encounter have their origin in the Asteroid Belt between Mars and Jupiter.

They are believed to originate from collisions, most of them glancing blows, between the smaller asteroids. Since such glancing blows must also impart velocity components to the fragments which are quite different from the orbits of the two asteroids that collided, the fragments must assume entirely different orbits. In a large num-

ber of cases, these new orbits will lead out of the Belt.

If this reasoning is correct, meteorities should be exceedingly rare beyond Jupiter.

In science fiction it is accepted as a fact that hard radiation causes mutations. If this is true, why have there been no known cases of mutation from the Hiroshima bomb?

Could it be that the radiation caused sterility instead?

Tony Stieber
6520 *West* 83*rd St.*
Los Angeles 45, *Calif.*

It is a fact that hard radiation causes mutations and this has been proved in the laboratory with fast-breeding fruit flies (*Drosophila melanogaster*). But it is also true that Hiroshima and Nagasaki did not produce a flood of human mutants.

There are two guesses in addition to your own:

One is that the resistance to mutation-causing radiation is much higher in mammals than it is in insects.

The other is that the mutations were so extreme that they could not have lived and thus they were miscarried.

When we send manned rockets out, first to the Moon and then to Mars and Venus, we have to include fuel for the return trip. It might take us years longer to develop a round-trip fuel and rocket than a one-way fuel and round-trip rocket. I would like to know the chances of finding fuels on the Moon, Mars and Venus, respectively.

David Shear
409 *Battery Lane*
Bethesda 14, *Md.*

It is highly unlikely that we would find substances which are raw materials for fuels on the Moon. I can't say that about Venus because its surface conditions are still unknown.

Mars has water and sunlight. By means of solar mirrors operating turbo-generators, we could break the water down into hydrogen and oxygen and liquefy these two gases. They would be a usable fuel combination. Or else we could only keep the oxygen in its pure form and convert the hydrogen, utilizing atmospheric nitrogen, into hydrazine. Hydrazine has many advantages of pure hydrogen, all of them falling under the heading of ease in handling.

But such processing, which amounts to a storing of solar energy, is quite complicated. When the time comes, we'll probably calculate twice whether it wouldn't be simpler to carry along the return fuel.